ACK/NAK BIT BUNDLING IN CARRIER AGGREGATION SCENARIOS

FIELD

[0001] The present invention relates to acknowledgement/negative acknowledgement (ACK/NAK, A/N) bit bundling in carrier aggregation scenarios. More specifically, the present invention exemplarily relates to measures (including methods, apparatuses and computer program products) for realizing ACK/NAK bit bundling in carrier aggregation scenarios.

BACKGROUND

[0002] The present specification generally relates to feedback control of downlink connections in carrier aggregation scenarios, especially in scenarios where time division duplex (TDD) is deployed.

[0003] In Long Term Evolution (LTE) Rel-10, the physical uplink control channel (PUCCH) format 3 only supports up to 20 ACK/NAK bits per feedback transmission. Hence, PUCCH format 3 can only support ACK/NAK feedback for TDD configuration 5 with up to two component carriers (CC), since in case of more CCs, more than 20 ACK/NAK bits would arise. In case of two CCs, a maximum number of ACK/NAK bits of 36 may arise. Hence, in case of two CCs (if the total number of ACK/NAK bits exceeds 20), spatial bundling is applied. At that, spatial (domain) bundling means that if two (more than one) codewords are transmitted per subframe, the ACK/NAK bits corresponding to each of the codewords are combined via an AND operation and the resulting bit is the spatial bundled ACK/NACK bit. In LTE Rel-10 in relation to PUCCH format 3 for TDD configuration 5, no time or carrier domain bundling is supported.

[0004] In LTE Rel-11, a user equipment (UE) configured with TDD configuration 5 and more than 2 CCs will be required to provide downlink (DL) peak data rates. In recent RAN1 meetings, the necessity of support of the ACK/NAK feedback in this case is raised and different bundling schemes to support the ACK/NAK feedback are discussed.

[0005] The following table illustrates the maximum number of ACK/NAK bits that may arise in the case of TDD configuration 5. It is to be noted that according to TDD configuration 5, a ratio of uplink (UL) subframes to DL subframes is set to 9:1. In particular, subframe 0 is set to DL, subframe 1 is set to DL/special subframe (guard periods), subframe 2 is set to UL, and subframes 3 to 9 are set to DL. As is derivable from the following table, in case of TDD configuration 5 and 5 CCs, the maximum number of ACK/NAK bits that may arise is 45 after spatial domain bundling.

	The number of CCs			
	2 CCs	3 CCs	4 CCs	5 CCs
Maximum number of A/N bits without bundling	36	54	72	90
Maximum number of A/N bits with spatial domain bundling	18	27	36	45

Hence, the problem arises that in a deployment with more than 2 CCs which uses TDD configuration 5, the required ACK/NAK bits, even if spatial bundling is applied, exceed 20, which is the maximum number of ACK/NAK bits that PUCCH format 3 can carry.

[0006] Hence, there is a need to provide for ACK/NAK bit bundling in carrier aggregation scenarios.

SUMMARY

[0007] Various exemplary embodiments of the present invention aim at addressing at least part of the above issues and/or problems and drawbacks.

[0008] Various aspects of exemplary embodiments of the present invention are set out in the appended claims.

[0009] According to an exemplary aspect of the present invention, there is provided a method comprising generating a set of acknowledgement bits confirming receipt of payload data of a radio frame in a carrier aggregation mode aggregating a primary and at least one secondary carrier, said radio frame being divided into a plurality of downlink subframes and uplink subframes, each of said downlink subframes comprising at least one codeword per carrier, each of said acknowledgement bits is allocated to one of said codewords of one of said downlink subframes, and applying spatial domain bundling and/or time domain bundling on said set of acknowledgement bits distinctive for each of said primary and said at least one secondary carrier, wherein said spatial domain bundling is an AND operation of all acknowledgement bits allocated to each codeword of one carrier of said primary and said at least one secondary carrier and one downlink subframe of said plurality of downlink subframes of said radio frame and said time domain bundling is an AND operation of all acknowledgement bits associated with corresponding downlink subframes of said radio frame.

[0010] According to an exemplary aspect of the present invention, there is provided a method comprising receiving an acknowledgement compilation, said compilation being a result of application, distinctive for each of a primary and at least one secondary carrier, of spatial domain bundling and/or time domain bundling on a set of acknowledgement bits confirming receipt of payload data of a radio frame in a carrier aggregation mode aggregating said primary and said at least one secondary carrier, said radio frame being divided into a plurality of downlink subframes and uplink subframes, each of said downlink subframes comprising at least one codeword per carrier, each of said acknowledgement bits being allocated to one of said codewords of one of said downlink subframes, and deriving success information of a transmission corresponding to said radio frame from said acknowledgement compilation based on said distinction for each of said primary and said at least one secondary carrier.

[0011] According to an exemplary aspect of the present invention, there is provided an apparatus comprising a generation module configured to generate a set of acknowledgement bits confirming receipt of payload data of a radio frame in a carrier aggregation mode aggregating a primary and at least one secondary carrier, said radio frame being divided into a plurality of downlink subframes and uplink subframes, each of said downlink subframes comprising at least one codeword per carrier, each of said acknowledgement bits is allocated to one of said codewords of one of said downlink subframes, and a bundling module configured to apply spatial domain bundling and/or time domain bundling on said set of acknowledgement bits distinctive for each of said primary and said at least one secondary carrier, wherein said spatial domain bundling is an AND operation of all acknowledgement bits allocated to each codeword of one carrier of said primary and said at least one secondary carrier and one downlink subframe of said plurality of downlink subframes of said